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Author(s): Kaufeld, Kimberly Ann
Kelly, Elizabeth J.
Stone, Timothy Amos
Karns, Tristan
Davis, John Taylor
Prochnow, David Adrian
Narlesky, Joshua Edward

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Los Alamos National Laboratory SAVY-4000 Field Surveillance Plan Update for 2021

Prepared by: Kimberly A. Kaufeld, Elizabeth J. Kelly, Timothy A. Stone, Tristan Karns, John Davis, David Prochnow, Joshua Narlesky, Los Alamos National Laboratory

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Contents

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1.0 INTRODUCTION

The Packaging Surveillance Program section of the Department of Energy (DOE) Manual 441.1-1, *Nuclear Material Packaging Manual* (DOE 2008), requires DOE contractors to "ensure that a surveillance program is established and implemented to ensure the nuclear material storage package continues to meet its design criteria." The Los Alamos National Laboratory (LANL) SAVY-4000 Field Surveillance Plan was first issued in fiscal year (FY) 2013 (Kelly et al. 2013). The surveillance plan is reviewed annually and updated as necessary based on SAVY-4000 surveillance findings, as well as results of the lifetime extension studies. Six surveillance plan updates have been issued, one in 2014 (Kelly et al. 2014), one in 2016 (Kelly et al. 2016), one in 2017 (Kelly et al. 2017), one in 2018 (Kelly et al. 2018) one in 2019 (Kaufeld et al. 2019) and one in 2020 (Kaufeld et al. 2020). This 2021 update documents what was actually done in 2020 and what is planned for 2021. Deviations from the 2020 surveillance plan were necessary because some of the planned surveillance containers were not available for examination.

The goal of the surveillance program is to provide data to:

- Evaluate container component performance over time against the initial baseline qualification;
- Validate the current SAVY container design life;
- Provide data for future design life extensions of components as indicated;
- Identify indications of container degradation and identify similar containers and/or contents that may need remediation;
- Maintain and continuously improve the surveillance information system that documents the complete life cycle of the containers including the initial production baseline, usage history, surveillance, and disposition;
- Identify container issues related to wear and tear that could indicate the need for a maintenance program for in-service containers prior to the end of the design life.

2.0 BACKGROUND

2.1 Past Surveillance Focused on Worst-Case Materials

In 2013, the Field Shelf-Life surveillance sample consisted of first identifying a set of "worst-case" materials that were packaged in non-standard containers, Hagan containers, or SAVY-4000 containers (Kelly et al. 2013). The worst-case materials packaged in non-standard or Hagan containers were repackaged into SAVY-4000 containers. The parameters used to determine worst-case materials were (1) for the O-ring, those materials with the potential for a high gamma dose to the O-ring, (2) for the container body, those materials containing potentially corrosive salts and with high radiation fields of all types, and (3) for the filter, those materials with the potential to generate corrosive gases and the potential for a high gamma dose to the filter. Figure 2-1 shows plots of dose versus item description codes (IDCs). The 12 IDC groups considered to encompass the worst-case materials are identified with blue stars. These groups were selected because they had a reasonable number of containers with the highest calculated doses and they encompassed the salt-bearing residues. (The doses are estimates used for ranking purposes only and do not represent actual dose to the components.)

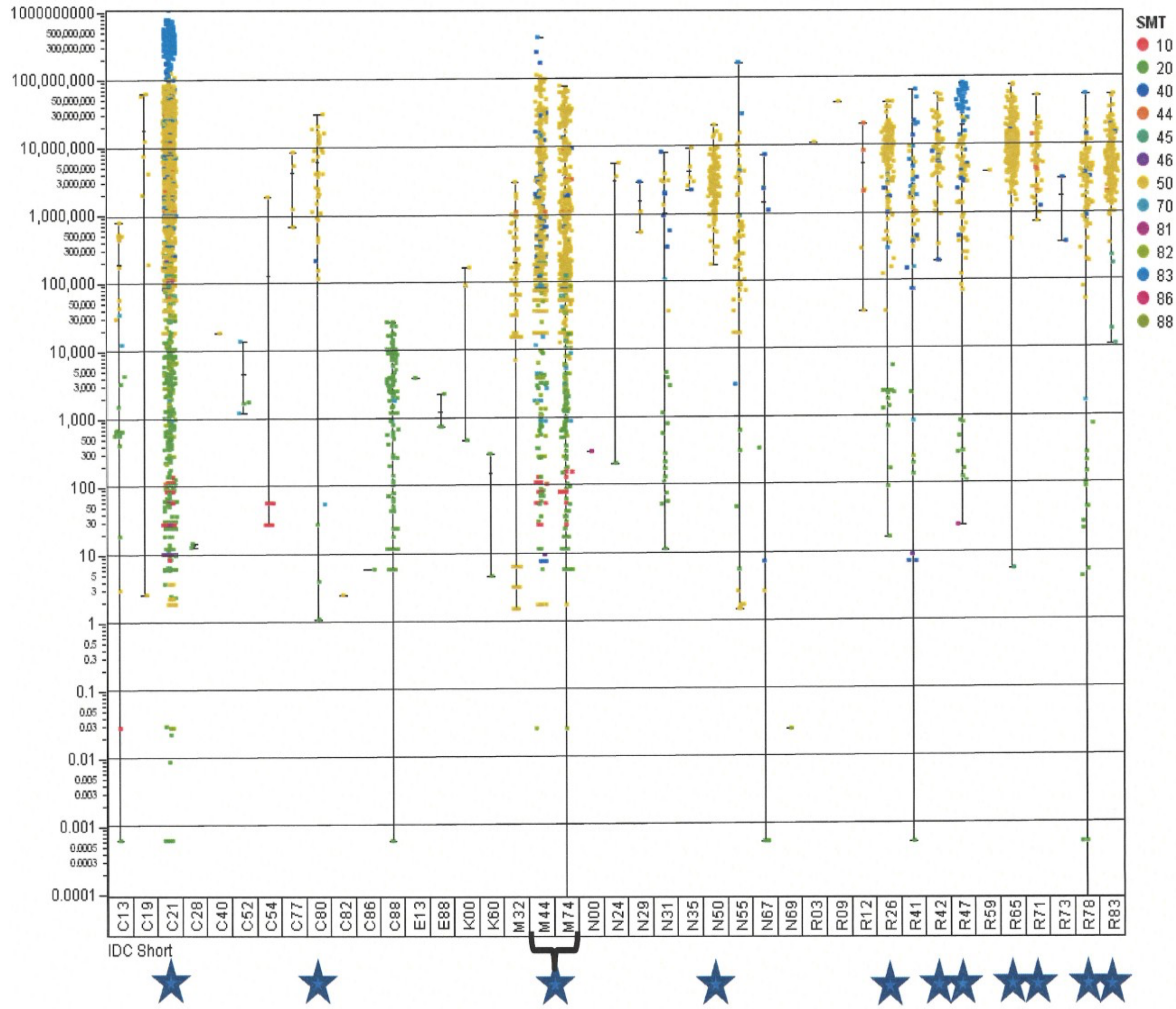

Figure 2-1. **Calculated dose for each IDC (see Appendix A for IDC definitions).**

The color of the dots on the graph indicate the isotopic composition (material type [MT]) of the nuclear material, e.g., weapons-grade plutonium, highly enriched uranium (see Appendix B for MT definitions).

In 2016 several items with corrosion had high wattage, which resulted in increased surveillance of items with high wattage (Kelly et al. 2017). A new IDC category was added in FY 2017, plutonium chloride (C19). This IDC was added because of it was considered to have a high potential for causing corrosion.

In 2020 container selection incorporated a random sampling plan along with engineering judgment (EJ) sampling. This approach, random sampling augmented with judgmental sampling, has been used by the 3013 Program since the initial surveillance guidance in 2005 (Kelly et al., 2005; Peppers et. al., 2009). The 3013 Program considers this approach to be a cost-effective tool for assuring the safe storage of the 3013 containers.

2.2 Engineering Judgment (EJ) Sampling

EJ sampling will continue to identify packages exposed to the most aggressive storage conditions with respect to radiation dose and potentially corrosive contents. As with the FY17, FY18, FY19 and FY20 surveillance plans, the FY21 surveillance plan will continue to target SAVY-4000 and Hagan using the following criteria:

- Storage container with similar/same IDC type as containers that showed corrosion.
- Worst-case IDC from the blue star groups (see Figure 2-1) that has not been tested previously.
- Specific to the Hagan population, IDCs not allowed as authorized contents per the SAVY Safety and Analysis Report (Anderson et al. 2013) but are currently loaded in Hagan containers.
- Preferential selection based on known degradation mechanisms from past surveillance activities (e.g., white powder generation in Hagan containers)
- Ensure at least two of each IDC grouping have been selected for SAVY containers on an ongoing basis so that these groupings are fully and continually represented.
- For storage containers that fall within the same IDC grouping, preference was given to containers/material types factors as follows:
    - higher in age
    - smaller in size
    - higher in wattage
    - higher in nuclear material content

These factors have been found to correlate with the degradation of PVC bags, resulting in higher rates of HCl generation, a concern for corrosion impacts.

Additionally, engineering judgment will continue to target material types that would result in higher alpha and/or gamma dose as well as a higher thermal load to the PVC bag. These conditions include continuing examination of Pu-238 (MT-83) containers; the addition of material types not previously examined include MT-82 (Np-237, which has a high gamma dose), and MT-41 and MT-42 (Pu-242, which is high in Am-241), large MT-56 and MT-57 (> 20% Pu-240, which are also high in Am-241) and MT-71 and MT-72 (U-233).

2.3 Random Sampling Incorporated into the SAVY Surveillance Program

In 2020 random sampling was added to the SAVY surveillance program. The random sampling follows the approach used by the 3013 Program ((Kelly et al., 2005; Peppers et. al., 2009)). In this approach, the number of containers randomly selected from a specified population is based on the requirement that, if a potential problem is in a specified percentage of the population, then at least one container from the potential problem group will be included in the sample.

A potential problem for a SAVY container is where the condition of the container, based on engineering judgment, could result in a significant safety hazard. Examples include, but are not limited to corrosion resulting in a through-wall breach, failure of the O-ring or filter, inappropriate use of the SAVY, etc. It should be noted that an important assumption of this approach is that a container has a valid assessment of its potential problem status when it is examined.

The SAVY program has specified the requirement for determining the random sample size as 95% confidence that a 5% potential problem will be identified. This requirement results in a random sample size of slightly less than 60 depending on assumptions, therefore, a sample size of 60 is adopted as the minimum size for the random sample.

The SAVY population is specified as those containers in service (or having been in service) by 2034 that are greater than five years old. The five-year requirement is consistent with the 3013 Program approach to assure that sufficient time has elapsed for potential problems to be detectable when performing surveillance (Peppers et. al., 2009)). Based on the current SAVY population (as of 2019), the random sample population size in 2034 is estimated to be 3176 (See Appendix C for details). Note that this does not mean that there are 3176 SAVYs in service in 2034 that are greater than five years old, it means that over the 15 sampling periods there will have been 3176 SAVYs over five years old. Those SAVYs in the random sample have been identified and cannot be removed from service before their sampling date without notification to the SAVY program.

Random sampling began in 2020 and will continue in 2021. At least four random containers will be examined each year over a 15 year period. At this sampling rate the 60 containers will be examined by 2034. However, this plan will be evaluated annually and adjusted as appropriate based on surveillance results. The plan for surveillance beyond 2034 will be developed based on the results of EJ and random sampling, as well as the results of on-going experiments to understand and predict corrosion impacts and other potential problems.

Appendix C contains a list of the 60 randomly selected containers. Not all of these containers exist at this time. The list is based on projections of when containers will enter the population. The process for selecting the 60 containers is detailed in Appendix C.

2.4 Leveraging MR&R Disposition

As the MR&R program plans to reprocess and consolidate, discard or disposition in the outyears, the container surveillance team will continue to review the SAVY containers identified under this program and will to the extent possible select engineering judgment (EJ) or items of opportunity containers from these groups.

2.5 Implications for Future Surveillance Based on SAVY Surveillance Data Trending Analysis

One of the goals of surveillance is to evaluate trends over time for those measurements that have quantitative values, e.g., Helium (He) leak rate, particle penetration, filter pressure drop, durometer (Shore M hardness), compression set (CS) and corrosion. A trend analysis of these measurements can support container lifetime extension assessments. In addition, a trend analysis can help identify containers whose measurements appear to be outliers when compared to those of the other containers and, therefore, should be considered for further surveillances. The results from the trending analyses, are found in Karns et al., 2020.

The corrosion trending analysis (Karns et. al. 2020) includes plots of corrosion ranks versus age and BDF. BDF is a value that incorporates age, wattage and container size. These are considered to be factors influencing corrosion.

The trending evaluations of corrosion for the SAVY 4000 and the Hagans indicate that high wattage and high BDF could result in an increased probability of having corrosion. There is considerable variability in the data and the limited number of observations (given the variability) is not sufficient for determining statistically significant results. However, with this limited data high BDF does better than wattage alone, indicating a possible interaction between wattage, age and container size. Nevertheless, containers with relatively low wattage and low BDF also have high corrosion level values. This finding indicates that additional factors may be important to understand and predict corrosion. For example, environmental factors such as relative humidity, which has been shown to be an important factor for corrosion.

3.0 CURRENT SURVEILLANCE PLAN

3.1 2020 Surveillance Containers

Table 3-1 below shows the containers selected for surveillance in 2020 (Table 3-2 in the 2020 surveillance update (Kaufeld, et al., 2020). A combination of 16 SAVY and 12 Hagan containers were listed in Table 3-2. If a surveillance container cannot be examined from this listing due to logistical issues, the surveillance plan allows the option to replace it by an item of opportunity (IoOP). In addition, IoOP containers can be identified from floor operations.

One IoOP container (20IoOp1) was self-identified from PF-4 floor operations in 2020, last item in Table 3-1.

The containers highlighted in yellow were examined in 2020, those items highlighted in green were not processed in 2020. Only two Hagans were processed in 2020. The remainder will be reconsidered in 2021 as part of the Hagan surveillance plan (Kelly, et al., 2020).

Surv ID (Random Sample Designation)	IDC Code	MT	IDC Description	Size (QT)	Item	Watt	Pu Wt. (g)	Age (yr)	BDF
20H1	R65	52	PROCESS RESIDUE; ER Salt	5	XBSOX441	1.285	488	20.07	2.26
20H2	R65	52	PROCESS RESIDUE; ER Salt	5	XBSOX431	1.274	484	20.16	2.25
20H3	R65	52	PROCESS RESIDUE; ER Salt	5	XBS9528	1.269	482	12.71	1.41
20H4	R65	52	PROCESS RESIDUE; ER Salt	5	XBS9535	1.266	481	12.4	1.38
20H5	R65	52	PROCESS RESIDUE; ER Salt	3	XBS1487	1.245	473	17.79	2.52
20H6	R65	52	PROCESS RESIDUE; ER Salt	3	XBS1482	0.977	371	19.52	2.17
20H7	R65	52	PROCESS RESIDUE; ER Salt	3	XBS8403	0.977	371	19.5	2.17
20H8	R47	56	PROCESS RESIDUE; Incinerator Ash	5	INC82701	1.767	347	14.4	2.23
20H9	R47	56	PROCESS RESIDUE; Incinerator Ash	5	INC83101	1.726	339	14.2	2.15
20H10	R47	83	Process Residue; Incinerator Ash	8	TDC70	9.3	19.7	17.0	9.76
20H11	C211	52	Pu 240 Compound impure oxide no major contaminant	5	PSP67156WPHOX	6.42	2440.07	3.20	1.49
20H12	C217	52	Pu 240 Compound impure oxide no major contaminant	8	BMB2C4	4.00	1520.00	3.36	0.72
20S1	R83	52	MSE Salt	1	XBLSCL4051203	7	432.15	1.2	1.95
20S2	R83	52	MSE Salt	1	XBLSCL1606	5.7	356	0.6	0.80
20S3	M74	52	METAL; Alloyed Metal	3	HNN5502CP	8.8	3351	7	6.98
20S4	R71	52	PROCESS RESIDUE; Salt	8	PCS68B1	2.14	811	6.7	0.88
20S4	R78	52	PROCESS RESIDUE; Sweepings/Screenings	5	VTB-16C1	2.67	1013	6.7	1.57

Surv ID (Random Sample Designation)	IDC Code	MT	IDC Description	Size (QT)	Item	Wat t	Pu Wt. (g)	Age (yr)	BDF
20S4	N50	52	NON-COMBUSTIBLE; MgO	8	ORF633956X BLC	0.65	248	6.7	0.27
20S6 (32)	M74	52 82	METAL;Alloyed Metal	5	HNN5216CF	5.59 5	2125	7.6	3.73
20S7 (75)	M44	52	METAL;Unalloye d Metal	5	PMP71205B	1.41	535.29	7.4	0.92
20S8 (108)	C21	52	COMPOUND;Di oxide	5	11530-3A	0	0	6.6	0
20S9 (119)	R42	52	PROCESS RESIDUE;DOR Salt	5	XBSOX153	2.84	1061	6.6	1.64
20S9 (132)	C21	52	COMPOUND;Di oxide	1	SCP-1741A	0.97	371.49	6.6	1.49
20S9 (174)	R42	52	PROCESS RESIDUE;DOR Salt	8	SLT1304	1.84	698.61	6.5	0.736
20S9 (203)	M44	52	METAL;Unalloye d Metal	8	R700121	11.1 8	4246.61	5.2	3.58
20S10	C217	52	COMPOUND;Di oxide/Impure No Major Contaminant	5	LZB225-RM640	6.04	2295.33	3.2	1.30
20S12	C217	52	COMPOUND;Di oxide/Impure No Major Contaminant	5	BMB21OXC1	5.98	2270.05	3.18	1.28
20S13	C212	52	COMPOUND;Di oxide; Multiple Alloys or Contaminants	5	CASKL2143	5.94	2256.42	3.17	1.27
20S14	C217	52	COMPOUND;Di oxide/Impure No Major Contaminant	8	LZB223-RS-183	5.73	2177.50	3.20	0.94
20S15	C217	52	COMPOUND;Di oxide/Impure No Major Contaminant	5	CXPROD192	2.35	893.00	3.75	0.45
20S16	C21E	83	Stringer	1	UAS-2634-K88	3.4	7.1	3.7	2.92
					UAS-2647-K88	3.4	7.1	3.7	2.92
					UAS-2909-H89	3.4	7.1	3.7	2.92

Surv ID (Random Sample Designation)	IDC Code	MT	IDC Description	Size (QT)	Item	Watt	Pu Wt. (g)	Age (yr)	BDF
					UAS-3020-B90	3.4	7.1	3.7	2.92
					UAS-2732-E89	3.3	7	3.7	2.92
20IoOP1	C213		Compound Dioxide Standard	5	LAO225BS	3.96	NA	15	NA

Table 3-1 2020 Identified Surveillance Containers

All but three SAVYs were put back into service in the same containers. Three containers in total were removed from storage service, one was due to damage caused by a drop as it was being taken down to the area in which surveillance is performed and the other was due to failing filter performance tests and the third was removed due to it being introduced into the glovebox. The two Hagans examined were processed or repackaged into SAVY containers. There was light corrosion on one of the Hagan containers, 20H12, likely from the degradation of the PVC bag.

Seven random sample SAVYs were surveilled in FY20, which provided interesting findings. The first ever failure of filter performance was observed in the random container 20S8(108). The failure in the filter performance was due to damage of the filter media from an object penetrating into it. This finding supports the premise that random sampling will find the unexpected. 20S9(119) was removed from service due to damage caused by a drop as it was being transported down to the area in which surveillance is performed. It also had considerable general corrosion on the inner surface of the SAVY, the most corrosion observed on any container in surveillance for FY20. 20S9(203) was removed due to it being introduced into the glovebox.

3.2 2021 Surveillance Containers

Table 3-2 shows containers that have been identified for 2021 potential surveillance based on engineering judgement, random sampling and trending. This 2021 surveillance plan assumes that the restriction on examining containers with >500 g soluble material (e.g., residues) has been lifted. Resource constraints limit the total number of containers that can be examined to approximately 15, and anywhere from 7 to 15 containers will be selected from this list. If logistical and/or resource constraints preclude choosing containers from this list, other containers may be substituted, e.g., items of opportunity, as long as they meet the selection criteria above.

Surv ID (random id)	IDC Code	MT	IDC Description	Size (QT)	Item Serial Number	Watt	Pu Wt. (g)	Age (yr)	BDF
21S1	R83	52 + 44	MSE Salt	1	XBLSCL4051203 021803055	7	432.15	2.2	1.75
21S2	R83	52	MSE Salt	1	XBLSCL1606	5.7	356	0.6	0.80
21S3	M74	52	METAL; Alloyed Metal	3	HNN5502CP 111103028	8.8	3351	7	6.98

Surv ID (random id)	IDC Code	MT	IDC Description	Size (QT)	Item Serial Number	Watt	Pu Wt. (g)	Age (yr)	BDF
21S4	R71	52	PROCESS RESIDUE; Salt	8	PCS68B1 041208028	2.14	811	6.7	0.88
21S5	R78	52	PROCESS RESIDUE; Sweepings/Screen ings	5	VTB-16C1 021205029	2.67	1013	6.7	1.57
21S6	N50	52	NON-COMBUSTIBLE; MgO	8	ORF633956XBL C 041208038	0.65	248	6.7	0.27
21S7 (400)	M44	51	Unalloyed Metal	8	10096 N/A	0	2	6.5	0
21S8 (340)	C88	36	U3O8	5	1620AQ 081305207	N/A	2215.8	6.75	N/A
21S9 (227)	C21	52	Dioxide	3	1734-COM 111103031	2.4	922.2	6.75	1.00
21S10 (276)	A75	38	Hemi	8	PSU21759N 111308093	N/A	N/A	6.25	N/A
21S11 (310)	A75	38	Hemi	12	UARI-MC2064-7472N 111312045	N/A	N/A	6.5	N/A
21S12 (trending)	C21	57	Dioxide	8	BLO-39-116-16 111308080	4.97	544	6.5	1.99
21S13 (trending)	R26	52	Filter Residue	5	ROTRBJ-1C1 031105051	1.19	452	19.7	2.66
21S14 (trending)	R83	52 + 44	MSE Salt	3	XBLSCL1217 121103083	2.85	178.5	8	2.58
21S15 (trending)	R42	52	DOR Salt	5	XBSOX153 091205175	2.84	1079.4	8	1.99
21S16	M44	42	Unalloyed Metal	3	GRING20-B 021803120	5.5	795.4	1	0.62
21S17	M44	42	Unalloyed Metal	3	GRING18 021803131	14.9	2166.6	N/A	N/A
21S18	M44	42	Unalloyed Metal	5	GRING20-A 081305042	16.3	2367.5	1	1.43
21S19	R65	52	ER Salt	5	XBS4955 081305197B	1.0	382.5	6	0.53
21S20	R65	52	ER Salt	8	GBS005 041208025B	4.9	1875	8.1	2.45
21S21	R65	52	ER Salt	8	GBS059 041208004B	4.9	1877	8.1	2.45
21S22	R65	52	ER Salt	8	XORER65SLT2 021608084	1.2	457	4.1	0.30
21S23	C21 (HATC H)	83	COMPOUND; Dioxide		SAVY (HATCH/3 from AAP020X) 041208057B	7	156.5	18.9	15
21S24	C21	52	COMPOUND; Dioxide	3	MOX51T 121103054B	6.2	2355.5	20.9	14.7
21S25	C21	56	COMPOUND; Dioxide	5	RBXS5657-2A 081305008B	10.5	2059	17.1	15.7

Surv ID (random id)	IDC Code	MT	IDC Description	Size (QT)	Item Serial Number	Watt	Pu Wt. (g)	Age (yr)	BDF
21S26	R47	54	PROCESS RESIDUE; Incinerator Ash	8	INCA-20 041208043B	3.7	830	N/A	N/A
21S27	R26	52	PROCESS RESIDUE; Filter Residue	5	ROTRB9C2 031105010B	1.5	576	N/A	N/A
21S28	M44	52	METAL; Unalloyed Metal	3	NAB183-2 121103013B	5.2	576	N/A	N/A
21S31	R83	52	PROCESS RESIDUE; MSE Salt	3	XBLSCL4051203 021803055	6.9	432.15	17.5	13.6
21S32	R47	54	PROCESS RESIDUE; Incinerator Ash	8	INCA-21 041208009	4	913	N/A	N/A
21S33	R83	52	PROCESS RESIDUE; MSE Salt	3	CAXBL128D 111103026	13.4	835	N/A	N/A
21S34	R78	52	PROCESS RESIDUE; Sweepings/Screenings	5	VTB-16C1 021205029	2.7	1013	N/A	N/A

In addition to the SAVYs on this list, a number of SAVY transfer containers will also be examined.

4.0 SURVEILLANCE MEASUREMENTS

The main focus of surveillance examinations is to evaluate O-rings, filters, and the condition of the metal surfaces, particularly for any sign of performance degradation, corrosion, or leakage. Measurements and examinations to assess potential problems are conducted on all surveillance containers. Because the previous surveillance showed corrosion in seven SAVY and nine Hagan containers, in this update there is increased emphasis on the guidance for corrosion examinations.

Some of these evaluations provide "yes/no" data and others provide quantitative data. If there is a "yes" response and/or there are any observations that indicate a potential problem with the container, the Board is notified as appropriate.

4.1 Non-Destructive Examinations (NDE) for SAVY-4000 and Other Surveillance Containers

Examinations during the unpacking of the outer container:

- Any visual indications of pressurization (slight bulging) or corrosion? (yes/no)
- Does visual inspection show signs of any dents or gouges that may have occurred in normal handling or possibly due to dropping the container? (yes/no)
- Weight measurement: do trends indicate moisture absorption or metal oxidation? (yes/no)

- Do contamination surveys show any indication of O-ring seal failure, weld failure, or filter failure? (yes/no)

Visual examination to determine inner package condition and if the container was packaged according to procedures:

- O-ring installed improperly? (yes/no)
- Inner container not consistent with material form (e.g., not a stainless steel slip lid for oxide, not a hermetically sealed lid for metal, etc.)? (yes/no)
- Bag-out bag not present? (yes/no)
- Bag-out bag not intact (e.g., contamination found outside bag-out bag)? (yes/no)
- Any liquid observed inside the bag-out bag? (yes/no)
- Metal inner container not intact (e.g., holes corroding through, plutonium in contact with bag-out bag, etc.)? (yes/no)

Examination of the empty SAVY-4000 or Hagan container:

- Leakage testing shall be in accordance with ANSI N14.5. For a SAVY-4000 container, the test pass rate shall be equal to the design release rate established as 5.6 × 10-6 cm^3s-1 of air. For both SAVY-4000 containers and Hagan containers, the testing helium leak rate criterion for this surveillance plan will be 1.0 × 10-5 atm cm^3 s-1 at a differential pressure of 10 kPa.
- Does the functional check of the closure system show any impingement of moving parts impeding closure? (yes/no)
- Does the O-ring groove on the body collar show any signs of damage (e.g., scratches, burr, etc.)? (yes/no)
- Are there dents? (yes/no)
- Do the interior and/or exterior surfaces of the container (particularly the weld region) show any signs of corrosion or discoloration? (yes/no).
    - If the response is "yes,"
        - a photograph of the affected area is taken
        - determine if container can be returned to service or further analysis for corrosion is required (in this case the container will have a DE [4.2]).

Examination of O-Ring:

- Does the SAVY-4000 O-ring need replacement based on the visual inspection: scratches, cuts or other damage on the O-ring itself that might prevent an effective seal? (yes/no)
- Shore M hardness measurements that will be evaluated using Parker O-ring manufacturer recommended tolerances. The hardness measurements will be directly compared with those measurements obtained from the accelerated aging studies and shelf-life studies.

- Compression set will be estimated from the measured thickness of the O-ring and the nominal thickness of Parker V0986-50 O-rings, 0.2100 inches ± 0.0005 inches. Initial thickness measurements will be made for SAVY containers going into the surveillance program. The estimated compression set values will be directly compared with those measurements obtained from the accelerated aging studies (Weiss et al. 2016).

Examination of Filter Function:

- Based on visual inspection of the outside of the lid, does the area around the filter show indications of deposits on or near the filter? (yes/no)
- Based on visual inspection of the inside and the outside of the lid, does the filter material itself show indications of discoloration or occlusion? (yes/no)
- Aerosol filter test at a flow rate of ~200 ml/minute with criteria pressure drop across the filter (<1 inch water column) and % penetration (<0.03%)
- Water penetration test of the PTFE membrane, 12-inch water column pressure applied on the exterior of the lid for a minimum of 1 minute with a visual inspection on the interior side of the lid to verify no water passed through the membrane (must be performed after the filter pressure drop test, or the filter must be properly dried to avoid a misleading pressure drop result)

4.2 Destructive Examination (DE)

In addition to the NDE measurements and qualitative evaluations that will be performed, if there is container component performance degradation, e.g., significant visual indication of corrosion, significant filter efficiency loss, pressure drop change, visual indication of filter/membrane color change, O-ring visual inspection failure and/or leak test failure, or as determined by SME judgment, then the container will undergo a DE. This is true for both SAVY and Hagan containers.

DEs to evaluate corrosion will include performing drop tests on some of the worst-case containers to investigate if the corrosion is affecting the ability of the containers to survive a drop. The containers will have helium leak tests both before and after the drop. The thickness of the containers will be measured prior to the drop using ultrasonic measurement devices. In addition, some of the worst-case containers, which are not drop tested, will be sectioned and the corrosion morphology (e.g., pitting and cracking) will be investigated using a laser confocal microscope (LCM). This LCM examination will include investigation of the interior weld region for signs of cracks. In addition, a series of mechanical property tests will be conducted using some of the samples taken from the containers.

5.0 REPORTING REQUIREMENTS

As stated previously, if there are any "yes" responses and/or there are any observations that indicate a potential problem with the container during the NDE and NDE/DE, Nuclear Material Storage personnel and the Board will be notified as appropriate.

An annual report summarizing the surveillance and lifetime-extension studies for all containers examined to date will be delivered to the Board in December. The SAVY-4000 Project Leader shall submit the report with assistance from staff members for each tested component.

6.0 SURVEILLANCE INFORMATION SYSTEM

A key component of the surveillance program is the surveillance information system (SIS). The SIS is comprised of multiple data sources including:

1. LA Authors
2. LANMAS
3. NucFil manufacturing quality data and Source Inspection data
4. Secured SAVY Surveillance Information

All SAVY reports are maintained in the LA Authors system. These reports include the annual surveillance report, the annual surveillance plan update, the safety analysis report, technical basis documents, life-extension reports, and all other key SAVY reports.

LANMAS contains important container information such as the age of the container, how long it has been in service, and its in-service history (e.g., what materials have been loaded for what periods of time). LANMAS also provides information about the materials in the containers, so that a material causing potential problems can be identified.

Surveillance items are placed on a feedlist prior to surveillance activities and items can be assigned to the LANMASfield SubMBA or MMGT. The MMGT identifier prevents the containers from being retrieved from the vault for purposes other than surveillance.

In addition, checks of the LANMAS database are run and results are reported on a biannual basis (beginning in 2019). These checks look for inappropriate storage configurations and/or conditions such as the presence of corrosive liquids, an inappropriate inner container for the material, wattage limit exceeded, and allowed time-in-storage exceeded.

NucFil manufacturing quality data and the corresponding source inspection data are currently maintained on the Gladson network share system. The point of contact for these data is Tim Stone. A “non-record” convenience copy of the source inspection data is maintained by David Prochnow. These data can be used for querying and analysis.

The surveillance data are stored on a secure system, which is currently maintained by Tristan Karns. The surveillance report presents and analyzes these data on a yearly basis.

7.0 FUTURE SURVEILLANCE

The surveillance program is evaluated annually and modified as necessary to adjust to observations and conclusions from annual surveillance reports and accelerated aging studies. The surveillance containers up until 2020 were chosen entirely by engineering judgement. In 2020 a random sampling component was added to the surveillance program. Again, this year, a randomly selected containers are included in the surveillance sample. The random sampling that began in 2020 will continue each year for a 15-year period.

In March 2021, some of the vaults experienced flooding. As this event may impact containers, the future surveillance plan will incorporate SAVY items that part of this event.

Although potential O-ring degradation rather than corrosion of the stainless-steel components was initially the driving factor for container selection, the container selection team has confidence based on surveillance results that the selection criteria (high heat load, high gamma dose, small diameter containers, longer storage times) effectively targeted corrosion containers.

As surveillance of SAVY containers continues into the future the it will incorporate the following considerations. Containers exhibiting corrosion and challenging contents will be kept in storage as long as reasonable so that aging effects in worst-case containers can be assessed. Lastly, items-of-opportunity will continue to be a source for surveillance containers.

7.1 Establishing Additional Surveillance Capabilities

Optical microscopy is currently performed on select containers which have been identified as having the most extreme corrosion. This has provided the program with valuable data with respect to the sizes of pits that have formed in some containers. However, the data obtained by optical microscopy is limited to measurements of a few pit diameters on a few containers. Laser confocal microscopy (LCM) can be used to obtain quantitative analyses of the pitting (width and depth), and is better suited to locate small cracks and could be used to assess whether stress corrosion cracking (SCC) is occurring in the storage population. Additionally, pit depth distributions obtained by LCM analyses would help to identify aging or environmental effects related to corrosion. Although corrosion of contaminated containers can be addressed through the visual inspection and in-glovebox optical microscopy (already established), LCM is better suited to examine container specimens for SCC. An established process exists in PF4 for the cleaning of contaminated metal specimens and removal from the glovebox line. Therefore, this process will be utilized to clean the selected contaminated specimens for LCM examination based on the results of the in-glovebox optical microscopy. An LCM is currently underway to established capability within PF-4, but outside the glove-box, which will aid in quicker turn around in performing these examinations rather than needing to release samples for examination on the current system located outside of PF-4.

One of the difficulties associated with the surveillance of older containers is the potential for radioactive contamination on the inside surface of the outer container (or containers that are actually contaminated). As a result, containers are introduced into the glovebox line at the time of opening, and a complete suite of analyses cannot be performed. Certain in-glovebox surveillance capabilities have been established to ensure that the three failure modes are addressed at least in a limited fashion. First, in-glovebox helium leak testing can be performed with an existing system. Contaminated containers for testing in the glovebox line are unloaded and cleaned prior to testing. Each container is then connected to the helium leak detector using an adaptor that attaches to the container vent. The testing is conducted using a helium leak detection system installed in a glovebox used for 3013 surveillance studies. This system differs from the current system used for container surveillance outside of the glovebox in that it is set up to perform helium leak testing under vacuum. It can be adapted to expand capability to address different container types.

In addition, enhancements in non-destructive testing techniques include the Modular Non-destructive Test System (MINTS)[1] providing a strong technical, financial, and environmental solution for analyzing plastic deformation and corrosion of nuclear material storage containers. The system combines ultrasonic (UT) and eddy current (ECA) detectors on a single platform, and its utility to test containers has been demonstrated. The use of MINTS in the surveillance program is expected to reduce the number of destructive tests necessary, thus maximizing the economic value of containers.

[1] Vaidya, R. U. et al., "Application of Non-Destructive Testing to Assess Corrosion Damage in Nuclear Material Storage Containers", LA-UR-19-23273; Los Alamos National Laboratory: Los Alamos, NM, 2019

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APPENDIX A. ITEM DESCRIPTION CODE (IDC) DEFINITIONS

IDC*	DESCRIPTION
C13	COMPOUND; Carbide
C19	COMPOUND; Chloride
C21	COMPOUND; Dioxide
C28	COMPOUND; Fluoride
C40	COMPOUND; Hydride
C52	COMPOUND; Nitrate
C54	COMPOUND; Nitride
C77	COMPOUND; Sulfate
C80	COMPOUND; Tetrafluoride
C82	COMPOUND; Trichloride
C86	COMPOUND; Trioxide
C88	COMPOUND; U3O8
C211	COMPOUND; Dioxide; High Purity
C212	COMPOUND; Dioxide; Multiple Alloys or Contaminants
C217	COMPOUND; Dioxide; Impure/No Major Contaminant
E13	REACTOR ELEMENT; Carbide
E88	REACTOR ELEMENT; U3O8
K00	COMBUSTIBLE; Non Specific
K60	COMBUSTIBLE; Paper/Wood
M32	METAL; Beryllide
M44	METAL; Unalloyed Metal
M74	METAL; Alloyed Metal
M74M	METAL; Alloyed Metal; Multiple Material Type Item
M447	METAL; Unalloyed Metal; Impure/No Major Contaminant
M742	METAL; Alloyed Metal; Multiple Alloys or Contaminant
N00	NON-COMBUSTIBLE; Non Specific
N24	NON-COMBUSTIBLE; Filter Media
N29	NON-COMBUSTIBLE; Glass
N31	NON-COMBUSTIBLE; Graphite
N35	NON-COMBUSTIBLE; HEPA Filter(s)
N50	NON-COMBUSTIBLE; MgO
N55	NON-COMBUSTIBLE; Non-Actinide Metal
N67	NON-COMBUSTIBLE; Plastics/Kim Wipes
N69	NON-COMBUSTIBLE; Resin
R03	PROCESS RESIDUE; Hydrogenous Salt
R09	PROCESS RESIDUE; Calcium Salt
R12	PROCESS RESIDUE; Calcium Metal
R26	PROCESS RESIDUE; Filter Residue
R41	PROCESS RESIDUE; Hydroxide Precipitate
R42	PROCESS RESIDUE; DOR Salt
R47	PROCESS RESIDUE; Incinerator Ash
R59	PROCESS RESIDUE; Oxalate Precipitate
R65	PROCESS RESIDUE; ER Salt
R71	PROCESS RESIDUE; Salt
R73	PROCESS RESIDUE; Silica

R78	PROCESS RESIDUE; Sweepings/Screenings
R83	PROCESS RESIDUE; MSE Salt
R83A	PROCESS RESIDUE; MSE Salt; Americum Contaminated
R260	PROCESS RESIDUE;Filter Residue;Non-Specific/No Further Detail Available
R470	PROCESS RESIDUE;Incinerator Ash;Non-Specific/No Further Detail Available
R712	PROCESS RESIDUE;Salt;Multiple Alloys or Contaminants
R832	PROCESS RESIDUE;MSE Salt;Multiple Alloys or Contaminants
R837	PROCESS RESIDUE;MSE Salt; Impure/No Major Contaminants

*The IDC codes used in this plan are abbreviated to the first three characters. Those used in LAMCAS are four characters.

APPENDIX B. DETAILED MATERIAL TYPES IN THE SURVEILLANCE POPULATION*

MT	DESCRIPTION
41	Pu-242-20% thru 60%
42	>60% Pu-242
52	Pu-239 with 4.00%–7.00% Pu-240
54	Pu-239 with 10.00%–13.00% Pu-240
56	Pu-239 with 16.00%–19.00% Pu-240
57	Pu-239- 19.00% and above of Pu-240
71	< 5 ppm U-232
72	5 to < 10 ppm U-232
82	Neptunium 237
83	Pu-238

* DOE Manual 470.4-6, *Nuclear Material Control and Accountability* (8-26-05).

APPENDIX C. DETAILS FOR THE SAVY RANDOM SAMPLING

The SAVY sampling population is specified as those containers in service (or having been in service) by 2034 that are greater than five years old. This sampling population is estimated to be approximately 3176 containers. To determine this number the age distribution for the current SAVY population (November, 2019) was determined (Table 1).

Table 1. Age Distribution of Current SAVY Population

Age (yrs)	Number
<1	408
1 to 2	227
2 to 3	181
3 to 4	148
4 to 5	192
5 to 6	34
6 to 7	102
7 to 8	76
8 to 9	8

This information was used to generate Table 2, which contains the number of SAVYs greater than 5 years for each year from 2020 to 2034. In Table 2 the assumption is that at least, on average, 200 containers will enter the >5 years old category each year beginning in 2025. This assumption leads to a total of approximately 3176 containers in the sampling population by 2034.

Table 2. Approximate Number of SAVYs in Sampling Population (> 5 years)

Year	Approximate Number of SAVYs >5 years	Number of SAVYs Entering Sampling Population
2020	220	192
2021	412	148
2022	560	181
2023	741	227
2024	968	408
2025	1376	200
2026	1576	200
2027	1776	200
2028	1976	200
2029	2176	200
2030	2376	200
2031	2576	200
2032	2776	200
2033	2976	200
2034	3176	

The R code “sample()” was used to select 60 containers randomly without replacement from the sampling population of 3176 containers (R Core Team, 2017). These containers are identified by the order of their first use dates. In the case of multiple identical first use dates, the orders are randomly assigned. The current plan is that at least four containers that currently exist in the sampling population will be examined each year.

In 2020, instead of four, seven random containers were examined (highlighted in green in Table 3). In 2021, five containers have been selected (highlighted in yellow). The others will be examined in the future. The plan has been developed so that an adequate number of containers are allowed to age before sampling. Containers in the random sample are tagged so that if they are removed from service before being examined, the SAVY program will be notified.

Table 3. The SAVY Random Sample Orders Through 2034

32	340	813	1542	2037	2606
75	400	853	1640	2062	2636
108	429	909	1667	2110	2693
119	462	989	1693	2163	2722
132	524	1020	1707	2194	2746
174	558	1175	1742	2288	2839
203	610	1234	1788	2332	2859
227	675	1295	1808	2363	2910
276	700	1373	1923	2431	3055
310	740	1493	1998	2553	3091

Minor variations to the assumption that at least 200 containers enter the sampling population each year starting in 2025 are not a problem as long as enough containers exist in a surveillance year to satisfy the random sampling for that year. For example, in 2034 there need to be at least 3091 containers in the sampling population and at least four containers from the random sample (for example 2859, 2910, 3055 and 3091) must be available for surveillance. Major changes to the sample population (e.g. many more containers in the sampling population than anticipated or many fewer) could require adjustments to the random sample.

Reference:

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